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How to Comply with Environmental Regulations? The Role of Information

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Abstract

The effectiveness of environmental regulation can be viewed as conditioned by the action of at least two main agents: the regulated firms and the public agency (the regulator). The agency's role is, on one hand, to enact environmental regulations and, on the other, to monitor firms' environmental behavior and enforce environmental regulations. The regulated firms, on the other hand, must be informed about the legal limits imposed on them and subsequently they must be able to comply with those limits. Using a questionnaire on the pulp and paper industry in Portugal we found that firms' decision to comply with environmental regulations is strongly influenced by firms' information on its legal obligations and that this effect is stronger for smaller firms. Moreover larger and younger firms are less likely to comply with environmental regulations than smaller and older firms. With respect to the public agency's behavior, we found that greater monitoring efforts are directed towards larger and younger firms, as well as towards those firms most likely to cause higher pollution levels.

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1. Introduction

Compliance with environmental regulations is a major issue in most countries since imposing a limit on firms' emissions does not secure a decrease in its emissions. For the objective of the environmental policy agency to be accomplished it is necessary that firms' behavior be monitored and the legal limits enforced. In addition, firms must be informed about the limits they are required to meet and must be able to comply with those limits.

Winter and May (2001) identified five sets of determinants for firms' decision to comply with environmental regulations: calculated motivations, normative motivations, social motivations, awareness of rules, and capacity to comply. The determinants depend on the firms, the community and the public agency responsible for creating the regulations, monitoring firms' performance and enforcing the regulations.

One precondition for firms' compliance with environmental regulations is firms' knowledge of the environmental regulations they must comply with. Winter and May (2001) found that firms' awareness of environmental regulations plays a crucial role on firms' environmental compliance.

Social motivations for compliance may also be present. Specifically, public disclosure of information on the degree of compliance with the environmental standards by firms may put additional pressure on firms to comply with environmental regulations. Afsah et al. (2000) found that public disclosure of information in Indonesia has induced a decrease in polluting emissions namely because it increases managers' information about their own plant's pollution and abatement opportunities. However this effect is stronger if public disclosure programs are implemented in conjunction with external effects such as effects on certification and on stock prices.

In sum, two issues related to information are essential for environmental compliance. On the one hand firms must be well informed about the environmental regulations they must comply with, and, on the other hand, public disclosure of information about firms' environmental performance may raise firms' perceived social duty to comply.¹

Firms' decision to comply with environmental regulation also depends on the behavior of the public agency that monitors and inspects firms' compliance. In other words, the decision to comply is also influenced by the enforcement and monitoring strategy of public agencies. These strategies influence the expected costs and benefits of compliance.² In particular, firms' expected costs and benefits of compliance are influenced by the likelihood of detection, the likelihood and amount of the fine and the cost of compliance. Winter and May (2001) found that the higher the probability of detection the higher the degree of compliance by firms; compliance is also greater if regulated firms think there is a stronger likelihood of a fine being imposed for a given violation.

With respect to the public agency's behaviour, Dion et al. (1997) found that monitoring is not random. Using plant-level data from the pulp and paper industry in Quebec, Dion et al. (1997) found that larger firms and firms whose activity may cause higher environmental damages have a higher probability of being inspected. The latter result lends support to the theoretical work on monitoring issues which, in general, predicts that monitoring activities occur more frequently at major sources of pollution

¹ This motivation for compliance is also designated as normative commitment by Burby and Paterson (1993).

² Winter and May (2001) designate the decision to comply by comparison of expected costs and benefits of compliance as 'calculated motivation' for compliance.

and at firms where the public agency believes that environmental requirements are being violated.³

Empirical research into these issues is, however, relatively little mainly due to data limitations. In this paper we propose to evaluate the extent of compliance by Portuguese firms in the Pulp and Paper industry with current air legislation and analyze possible determinants of firms' compliance behavior with a particular emphasis on firms' information about their legal obligations. We found that this is an important problem in the Pulp and Paper Industry in Portugal. Therefore it is important to improve the information channels on environmental legislation towards the firms. Additionally we investigate the determinants of the agency's decision to monitor and inspect polluting firms. The data used was collected by a national survey of Portuguese firms in the Pulp and Paper industry conducted in June 1999.

The paper is organized as follows. Section 2 provides a summary of Portuguese legislation on air pollution with special emphasis on the issues relating to the Paper and Pulp Industry. Section 3 presents the survey instrument elaborated to investigate the information firms have on the environmental regulations applicable to them, the degree of compliance with those regulations, and the agency's behavior with respect to inspections. Section 4 contains the characterization of compliant versus noncompliant firms and informed versus non-informed firms and tests for the role of information on firms' decision to comply with regulations. Section 4 also contains the analysis of the determinants of agency's behavior regarding its decision to inspect firms. Concluding remarks are offered in Section 5.

³ Russel et al. (1986) and Cohen (1999) provide excellent surveys of the literature on monitoring issues. One common feature of this literature is the assumption that the probability of inspection depends on the relation between the firms' effective pollution and allowed pollution. More recently, formal game theoretic work on these issues has focused on providing a rationale for this assumption by explicitly modelling the strategic incentives of the parties (firms and inspection agencies) involved in such settings (see, for example, Franckx (2001a, 2001b)).

2. Institutional Background

Portuguese environmental regulation's fundamental text was published in April 1987. Under article 8, all activities that release harmful emissions to the environment are subject to special regulation. In particular, polluting activities are subject to a licensing process and their emissions are subject to limits established in specific legislation. Moreover, if the legal limits on emissions are not met, state agencies may apply fines and sanctions. One possible sanction is to cease the activity, and in some cases judicial actions may also be taken.

The control of polluting emissions from fixed sources is defined in a separate legal text (Dec. Lei 352/90, November 1990). Plants that generate emissions subject to legal limits⁴ must self-control their emissions. The control is either continuous or periodical,⁵ and the state agency may perform monitoring activities whenever it finds it adequate.⁶ The legal limits⁷ are set according to three criteria: existence of adequate control technology, economic effects on the plants, the well-being of the population and of the environment. Non-compliance with the obligations and limits set in the present legal text are subject to fines.⁸ The law also establishes that all negligent behavior is punishable. Finally, article 30^o creates an environmental tax on pollutants. The objective

⁴ The classification of the activities subject to limits on the release of polluting emissions and the limits for each type of pollutant is established in Portaria 286/93, March 12. The pollutants controlled by this text are sulphur dioxide, lead, particles, ozone, and carbon monoxide.

⁵ The definition of the type of control of emissions that plants must perform is set according to criteria defined by European Union regulations, or if these do not exist it should be defined by the state agency at the time of the licensing process.

⁶ The state agency must install control stations of air quality in areas where pollution is expected to be high, and that are representative of the local conditions. If the information on emissions reveals concentration levels above the limit concentration level of pollutants, the state agency may declare the area as exceptional, which implies the definition of a plan to reduce emissions and its information to local plants and general population accompanied by a financial plan to help cope with the new levels. This specific legal text confirms the bias of environmental state agencies towards the control of polluting emissions in areas where environmental damage is expected to be high. This bias was also found in enforcement activities by Dion et al. (1998).

⁷ The limits may be revised at least every five years, except if the European Union regulations change.

⁸ The limits of the fines are set in the general legislation.

of the tax consists in raising revenues for air pollution control initiatives⁹ and is a function of the amount of emissions in the previous year.

3. The Survey

The Paper and Pulp Industry is an important source of air pollution from fixed sources. It is also a sector composed of plants of different sizes located in several districts. As such, this sector constitutes a good case study that might enable us to make important inferences for other polluting sectors as well.

The survey is composed of two parts.¹⁰ The first part consists on questions regarding a general characterization of the firm. Some questions are on the date of birth, location, subsector of activity,¹¹ sales revenues, number of workers, percentage of foreign capital, etc. The second part is on the evaluation of the degree of information firms have about the legislation that covers their activity. Some of the questions under evaluation are the licensing process, the environmental impact study, the knowledge of the level of risk that was attributed to the firm as a function of the activity developed, and the risk that the activity implies to humans and the natural environment. We also question firms on their agreement/disagreement with some pieces of environmental legislation. Finally, questions on specific aspects of the legislation are included. These aspects are emissions' limits, measurement of emissions and means of emissions release (chimneys). The survey was mailed to all firms in the Paper and Pulp Industry in Portugal excluding firms with less than 5 paid workers, and answers were also received by mail.¹²

⁹ The tax may be used to finance plants' investments in pollution abatement.

¹⁰ The survey is available from the corresponding author upon request.

¹¹ The Paper and Pulp industry is divided into four subsectors: Pulp Mills (21110); Paper and Paperboard Mills, except corrugated (21120); Paper and Paperboard Mills, including boxes (21211); Other Paper and Paperboard boxes (21212).

¹² A self addressed stamped envelope was sent together with the survey.

4. Results

A brief characterization of the firms in the sample¹³ is depicted in Figure 1. Firms are distributed by 9 districts with a higher concentration in Aveiro, Lisbon, and Porto. Half of the firms are in subsectors 21120 and 21212. With respect to size of the firms, 44% of the firms have more than 50 workers (29.4% have more than 100), and 44% of the firms have sales revenues higher than 750 000 000 PTE.¹⁴ Most firms were created after 1960, and 18% were born after 1990. Finally, 58.8% of the firms are located in an industrial park, but 20.6% are located in residential areas.

(Figure 1 about here)

Figure 2 shows the distribution of firms classified in four types according to the information firms have and their compliance with environmental regulations. We conclude that informed firms comply more with environmental regulation than uninformed firms (34.3% compared with 11.4%). In addition, the percentage of informed firms is higher within the group of compliant firms than within the group of noncompliant firms.

(Figure 2 about here)

¹³ Concerns about the representativeness of the sample led us to perform some statistical tests (binomial, and zM tests – see, for example, Conover (1980)) since only 34 of the 173 surveys mailed were returned complete. We tested the representativeness of the sample with respect to four variables on which we had information for the sample and the population. The variables were: district of location, subsector of activity, number of workers and sales revenue. We concluded that our sample was representative with respect to district of location, number of workers and sales revenue. This analysis is available from the corresponding author upon request. Although the results indicate that the sample is representative, there is also the question about whether the firms that returned the survey are, in some other aspects, different from the ones that did not respond, but we have no means to evaluate this hypothesis.

¹⁴ 750 000 000 PTE is approximately 3 750 000 Euro.

To evaluate in more detail firms' information about the environmental legislation applicable to this sector of activity, and the degree of compliance with that legislation, we selected only some of these requirements given the large number of legal dispositions. In particular we examine whether firms creation was preceded by an environmental impact study (EIS). We found that among the firms created after 1990 that were required to have had an EIS only 16.7% were complying with the legislation in this respect. However, among the firms that received a monitoring team (53% of all firms) 28% had an EIS.

With respect to polluting emissions, we found that the number of firms that release substances above a specific level established in the regulation and consequently should control emissions continuously but do not do it varies between 62% and 75%. However, all firms that had not been visited by a monitoring team were not complying with the legislation in this respect. Among monitored firms, approximately 50% were in compliance.

Finally, firms were questioned about the characteristics of their chimneys. We found that approximately two thirds of the firms had chimneys with the required height, but only 50% were complying with other requirements for the chimneys. Monitored firms did not differ from non-monitored firms in this respect.

However, monitored firms are in some other aspects different from non-monitored firms. In particular, the incidence of agency inspections is higher in larger firms.¹⁵ About 70% of the firms with more than 100 workers had been inspected, and 64% of the firms with sales revenues higher than 1 000 000 PTE had also been inspected. The incidence of agency inspections is also higher in firms whose activities

¹⁵ The terms used to describe types of compliance inspections are not standardized in the literature. Here we use the terms "monitored firm" or "inspected firm" interchangeably to mean that the firm has been subject to a *monitoring visit* where agency staff conduct measurements to determine concentrations and rates of discharge of pollutants.

generate high levels of risk for humans and the environment. About 73% of the firms that had been classified by the state agency as presenting a high risk activity had been inspected, while only 44% of the firms presenting low or no risk activity had been inspected.

Table 1 presents probit estimates of the effects of these two variables (size of the firm as measured by the number of workers in the firm, and level of risk) on the probability of a firm being inspected, while controlling as well by the age of the firm. The latter variable is measured by a dummy variable taking the value of 1 if the firm was born after 1990, and the value of 0 otherwise. Since many pieces of the Portuguese environmental regulations in the Paper and Pulp industry apply only to firms created after 1990 (e.g. the requirement to have an environmental impact study), one could expect a concentration of monitoring activities on these firms and, as a consequence, a positive effect of this variable on the probability of an inspection.

(Table 1 about here)

The results suggest that younger firms and high risk firms are more likely to be inspected than older and low risk firms, but the effects of these variables are not statistically significant at conventional levels of significance (below the 0.1 significance level). A statistically significant determinant of the probability of inspection is the size of the firm. The results show that, all else the same, large firms are more likely to be inspected by the state agency than small firms.

Characterizing non-compliant firms we found that most firms not in compliance with the legislation or not correctly informed belong to the Paper and Paperboard Mills,

except corrugated (21120), are located in Lisbon, have sales revenues above 1 000 000 PTE, and hire more than 100 workers.¹⁶ Moreover, 23% of the firms ignore the purpose of the environmental tax which is, namely, to finance investments that reduce the release of polluting emissions. However, with respect to the specification of the emissions' release equipment, 50% of the firms have the adequate equipment with correct specifications and measurement process. The other half, either do not have the equipment, ignore the amount of emissions that release, or ignore the limits on emissions set by specific legislation. This finding emphasizes the need to improve the information to firms on their legal obligations as a precondition for enforcement.

Table 2 presents probit estimates for the determinants of firms' compliance with the applicable environmental legislation.¹⁷ The independent variables considered are the information status of the firm (a dummy variable taking the value of 1 if informed, and the value of 0 otherwise), the risk level of the firm's activity, a dummy variable indicating whether the firm was created after 1990, the size of the firm, as well as an interaction variable formed by interacting the size of the firm with the information status of the firm.

(Table 2 about here)

¹⁶ The finding that noncompliant and/or misinformed firms are primarily located in Lisbon is somewhat surprising given that Lisbon is the wealthier district of the ones analyzed. Moreover, these firms are large firms with respect to number of workers and sales revenues. We would expected that larger firms and firms located in wealthier areas would be better informed since public pressure is expected to be stronger in this type of communities as suggested by Pargal et al.(1997).

¹⁷ As noted previously, the present study is limited by the data set used. First, participation in the study was voluntary and, consequently, it is possible that firms that did not return the survey have distinguishing characteristics from those that did return it. However, it seems reasonable to assume that those participating in the study were the ones more likely to care about the issue under analysis. In addition, we are assuming that participating firms answered truthfully to the questions posed in the survey. Nevertheless, it is plausible to assume that if anything firms would underreport noncompliance. So, in a sense, our results might overestimate compliance by Portuguese firms in the paper and pulp industry.

Inspection of Table 2 reveals that firms created after 1990 are less likely to be in compliance with the environmental legislation than older firms, an effect that is both statistically significant and quantitatively large. The results also suggest that high risk firms are less likely to comply with the environmental legislation than low risk firms, but the effect is not statistically significant. Very important to our analysis is the effect of information on firms' compliance with the legislation. The results in Table 2 show that informed firms have a higher probability of compliance than uninformed firms. This effect is statistically significant and the magnitude of the estimate reveals the importance of being informed. This result is extremely important for policy since it suggests that increasing the number of informed firms significantly increases the probability of compliance with environmental regulations. The effect of information on the probability of compliance, however, varies with the size of the firm. In particular, the regression results suggest that information about environmental obligations decreases the probability of compliance for larger firms. These results, however, suffer from the assumed monotonicity in the relationship between compliance behavior and size. The importance of the small, intermediate and large firms in the general probit result obtained might vary however considerably.

In order to best evaluate the effect of the interaction between the information status of the firm and its size on the probability of compliance, we generated predicted values for the probability of compliance according to the information status of the firms. To do so, we first estimated separate probit models for the sub-samples of informed and uninformed firms using the same set of independent variables as the ones used in the regression shown in Table 2 excluding the variables pertaining to the firms' information status (results not shown¹⁸). We then classified the firms into three size classes, namely firms with less than (or equal to) 25 workers, firms with between 26 and 50 workers,

¹⁸ These results are available from the corresponding author upon request.

and firms with more than 50 workers. Finally, for each size class, we predicted the probability that each firm would comply with the environmental legislation based on that firm's characteristics and the compliance behavior of the *informed* firms. Next we averaged these predicted probabilities across all informed firms for each size class.¹⁹ Thus for each size class we formed the average probability that the informed firms in our sample would comply with the environmental legislation. We repeated an identical prediction procedure using the estimated coefficient vector from the *uninformed* firms to predict the average probability that the uninformed firms would comply with the applicable environmental legislation. The results of these predictions are reported in Table 3.

(Table 3 about here)

The results show that uninformed medium-size firms have a higher probability of compliance than uninformed small firms, but a lower probability of compliance than their large size counterparts. However, tests on the equality of these predicted probabilities across the size classes of uninformed firms reveals that they are not statistically different at conventional levels of significance, a result that accords with the regression results reported in Table 2.²⁰ Also in accordance with the regression results in Table 2, we find that the larger the size of informed firms, the lower is the probability of their compliance with the applicable environmental regulations. However, tests on the equality of these predicted probabilities across the size classes of informed firms

¹⁹ There are two methods to generate predictions from a dichotomous choice model such as the probit. The first is to evaluate the index function using the characteristics of each firm, and then evaluate the probability of compliance for that firm. These probabilities can then be averaged over the sample. The second method is to use the same initial procedure, but use the predicted individual probability of compliance to assign the firm as being either a compliant firm or a non-compliant firm depending on whether the predicted probability exceeds $\frac{1}{2}$. These predicted dichotomous observations can then be averaged over the sample. We prefer to use the first method as it retains more information than the second method.

²⁰ The tests of the null hypothesis that the predicted probability of compliance for small uninformed firms is less than the predicted probability of compliance for medium-size and large uninformed firms yielded a test statistic $z=-0.42$ (p-value=0.34) and $z=-0.19$ (p-value=0.42), respectively. The test of the null hypothesis that the predicted probability of compliance for medium-size uninformed firms is higher than that for large uninformed firms yielded a test statistic $z=0.30$ (p-value=0.38).

reveals that the probabilities of compliance of small and medium-size informed firms are not statistically different. The probability of compliance of large informed firms is significantly lower than the probability of compliance of both small and medium-size informed firms.²¹ Thus, the effect of firms' size on the probability of compliance differs according to the information status of the firms. Specifically, the size of the firm has no significant effect on the probability of compliance of uninformed firms. On the other hand, the size of the firm is a significant predictor of the probability of compliance of informed firms. There is, however, non-monotonicity in the relationship between compliance behavior and size of informed firms. In particular, the probability of compliance of *large* informed firms is significantly lower than the probability of compliance of small and medium-size informed firms.

The results in Table 3 also show that the impact of information on the probability of compliance varies with the size of the firm. Specifically, information about the applicable environmental regulations increases the probability of compliance of small and medium-size firms. The probability of compliance of large firms is, on the other hand, negatively affected by information. Formal statistical tests were conducted to determine the statistical significance of these apparent differences in compliance behavior. These are reported at the bottom of Table 3. The results show that the effect of information on the probability of compliance is statistically significant only for small firms. The probability of compliance of large and medium-size firms is not statistically different between informed and uninformed firms. In sum, we find that the effect of information on compliance is larger and statistically significant for smaller firms. Thus government' efforts to increase compliance should concentrate on providing

²¹ The tests of the null hypothesis that the predicted probability of compliance for small informed firms is higher than the predicted probability of compliance for medium-size and large informed firms yielded a test statistic $z=0.64$ ($p\text{-value}=0.26$) and $z=2.21$ ($p\text{-value}=0.01$), respectively. The test of the null hypothesis that the predicted probability of compliance for medium-size informed firms is higher than that for large informed firms yielded a test statistic $z=1.40$ ($p\text{-value}=0.08$).

information to firms about the regulation and that effort is especially fruitful in smaller firms.

5. Conclusion and discussion

One of the most pressing problems the international community faces today is the degradation of the natural environment. Decision makers and planners at all levels of government face an increasing pressure from the public to protect the environment. Generally speaking, one of the major devices that society has at its disposal for implementing environmental protection is regulation, monitoring and enforcement. Securing compliance with pollution regulations, however, is not an easy task. First, many regulatory schemes may not be properly designed or, even if properly designed, may not be implemented effectively. Secondly, even when environmental agencies make enforcement efforts, firms may find ways around requirements and the outcomes may be different than those anticipated by the regulator. The monitoring and enforcement behavior of environmental agencies, as well as the compliance behavior of firms have been the subject of extensive theoretical work, with substantial contributions from scholars in political science, public policy and economics, but they are still not well understood empirically. The reason is that, mainly due to data limitations or data unavailability, empirical research on these issues lags woefully behind theoretical research. In an attempt to broadening our understanding of these issues, this paper uses data from the Portuguese pulp and paper industry to analyse the environmental agencies' behavior with respect to the monitoring of environmental requirements and the firms' decision to comply with those requirements.

Four main sets of findings emerge from our analysis. First, and in line with the findings of Dion et al. (1997), the results provide moderate evidence that greater

inspection efforts are allocated towards those firms whose activities may cause higher environmental damage and towards younger firms where environmental requirements are more likely to be violated given the stronger requirements applicable to these firms. These results provide empirical support to the assumption in most theoretical work on monitoring issues that the probability of inspection depends on the relation between the firms' effective pollution and allowed pollution. In addition, these results also lend support to the public interest theory of regulation (Posner (1974)) that views the purpose of regulation, including environmental regulation, as the enhancement of social welfare via improved efficiency in resource allocation, and considers that the public agencies faithfully pursue the implied allocative objectives. The empirical results also provide compelling evidence that, all else the same, larger plants face a higher probability of being inspected. This result is in line with Dion et al. (1997)'s finding that the greater the "visibility" (measured by the importance of the firm in the labor market) of the firm, the larger the number of inspection actions it faces.

Second, the results indicate that, *ceteris paribus*, younger firms and firms whose activities are more likely to cause environmental damage are less likely to be in compliance with the applicable environmental regulations. This result might seem somewhat surprising given that these are exactly the firms that are more likely to be subject to inspection actions. However, as noted previously, firms' decision to comply with environmental regulations depends not only on the likelihood of a violation being detected and the penalties associated with non-compliance, but also on the probability that penalties will be imposed. If polluters do not expect environmental agencies to have the political clout and resources needed to enforce regulations, they have little (if any at all) incentive to undertake any costs of compliance, and this is even more so where

these costs are high as they are in high risk firms and younger firms with stronger environmental requirements.

The third set of findings emerging from our analysis concerns the role of information and size on firms' compliance behavior. The data for the Portuguese pulp and paper industry show that there is a considerable degree of misinformation with respect to firms' own emissions and environmental regulations. In particular, many firms ignored the amount of emissions they release, the type of measurement they are mandated to do, and the purpose of the environmental tax. The last point is particularly important since the investments firms do in emissions' abatement are deductible from the tax. So it is in their best interest to invest in this area. The results of our multivariate analysis also show that the effect of information on firms' probability of compliance is strong and statistically significant. For small firms, the probability of compliance goes from 33% if they lack information about the environmental regulations to 82% if they do have information. This indicates that one important way to improve environmental compliance by firms is to increase firms' knowledge of environmental regulation. Afsah et al. (2000) found that one of the advantages of the public disclosure information program in Indonesia, pointed by firms, was to improve firms' information on their emissions and abatement opportunities. This suggests that an effective way to improve firms' information might be including in the Portuguese regulations the requirement of publicly disclosing information about firms' environmental performance.

Finally, our results reveal that large informed firms are less likely to comply with environmental regulations than smaller informed firms. The identified combination of a positive effect of firms' size on the probability of inspection and this negative effect of size on the probability of compliance suggests that environmental agencies may be monitoring larger firms for visibility of their actions, but avoiding enforcing

environmental regulations for these larger firms. In a sense, this agrees with the notion that firms employing more workers may (knowingly) benefit from some leniency in enforcement of penalties because regulators may be reluctant to take decisions that risk the jobs of many workers (Field (1997)). To a degree, this result also lends some support to the economic theory of regulation (Stigler (1971), Peltzman (1976)) that would view public agencies as allocating monitoring resources in a way that maximizes political support. In line with this view, the public agency may obtain political support from the environmentally concerned community by undertaking “visible” inspection actions and, simultaneously, obtain political support (or, at least, not losing it) from those that benefit from the existence of large firms by engaging into less enforcement actions with respect to these firms (Dion et al. (1997)). Thus, our results suggest that, rather than substitutes, the public interest and the economic theories of regulation should be viewed as complementary in explaining the agencies’ decision to inspect firms. Moreover, in addition to informational issues, our overall results suggest that enforcement is probably the weakest link in the environmental protection chain in the Portuguese pulp and paper industry.

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Figure 1: Sample characteristics

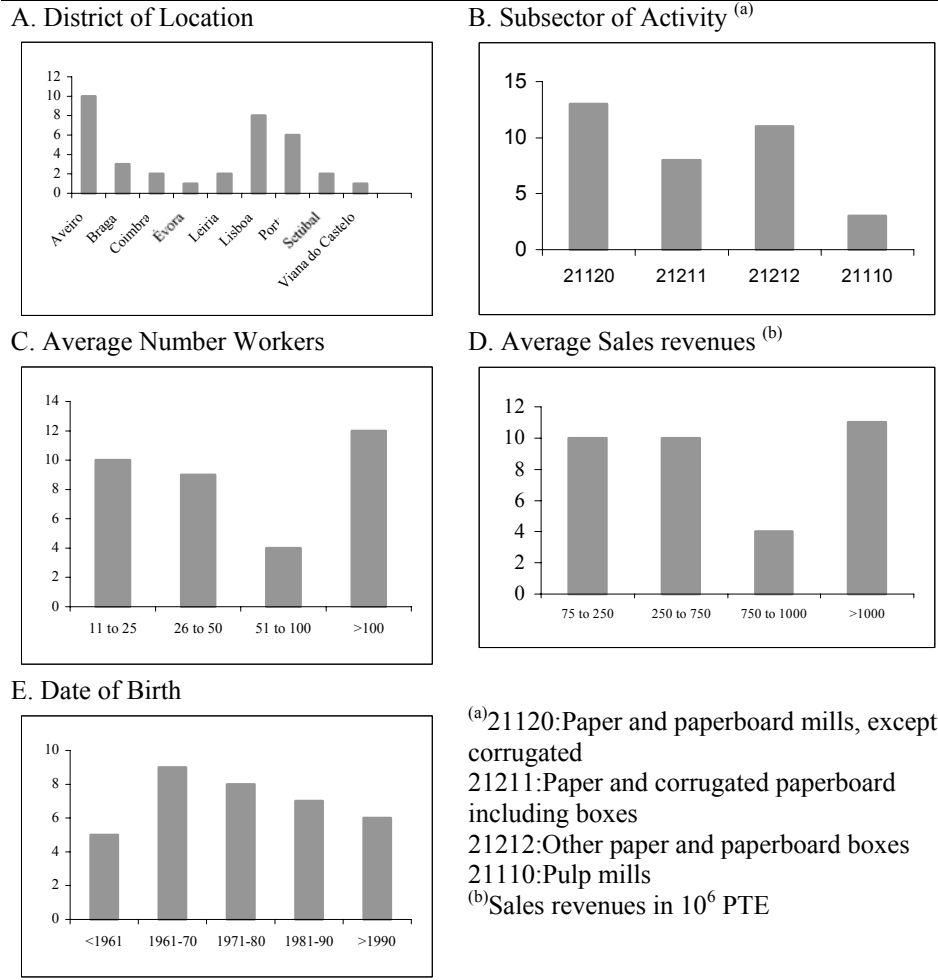


Figure 2: Distribution of firms according to compliance and information status (relative frequencies)

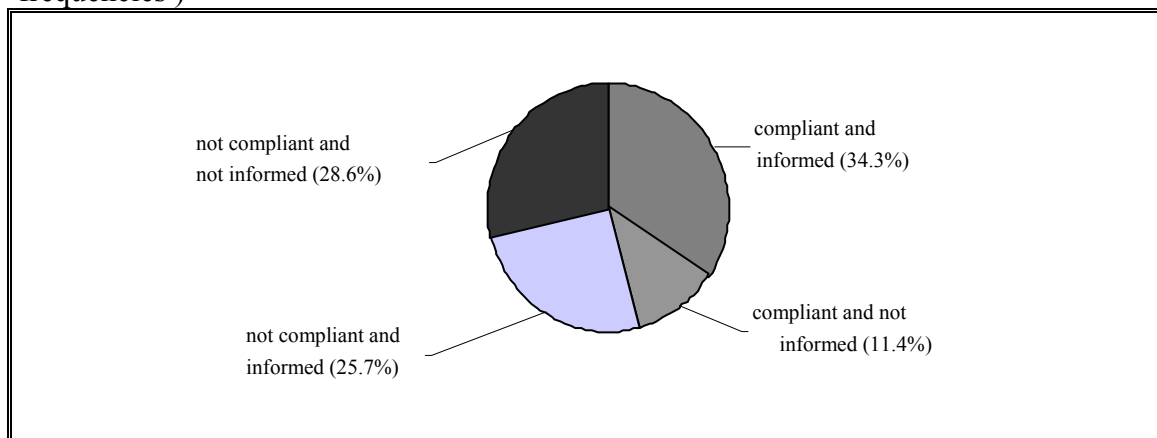


Table 1 – Probit estimates for determinants of monitoring by the state agency

Variable	Coefficient	Std. Error	z-Statistic	p-Value
Intercept	-1.277	0.646	-1.98	0.048
Risk	0.693	0.532	1.30	0.193
Year>90	0.282	0.581	0.49	0.627
Workers	0.332	0.174	1.90	0.057
Log-likelihood	-20.358			
χ^2 _statistic (p-Value)	7.50 (0.057)			
Percent correct	64.71			
Sample size	34			

Table 2 – Probit estimates for determinants of compliance

Variable	Coefficient	Std. Error	z-Statistic	p-Value
Intercept	1.139	1.480	0.77	0.442
Informed	1.906	1.021	1.87	0.062
Workers	0.006	0.011	0.58	0.561
Informed×Workers	-0.027	0.016	-1.76	0.079
Risk	-0.404	0.292	-1.38	0.167
Year>90	-1.226	0.652	-1.88	0.060
Log-likelihood	-18.072			
χ^2 _statistic (p-Value)	8.83 (0.116)			
Percent correct	76.47			
Sample size	34			

Table 3 – Predicted compliance probability according to the firms' size and information status

	Number of Workers		
	≤ 25	[26-50]	> 50
Not Informed	0.327	0.517	0.394
Informed	0.816	0.658	0.265
	H0: diff < 0 z = -1.551 P < z = 0.060	H0: diff < 0 z = -0.347 P < z = 0.364	H0: diff > 0 z = 0.487 P > z = 0.313